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DYNAMIC SKIAMETRY*

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Static skiametry is an objective method for the determination of the refractive status of an eye when the eye is in a condition of passively fixating a distant object. Dynamic skiametry, on the other hand, is an objective method for the determination of such quantities of lenticular power as will make the retina of the active or dynamically functioning eye and the object fixated (which is placed ordinarily at a relatively close distance to the eye, such as the normal reading distance) conjugate points. In static methods of skiametry accommodative suppression and relaxation are demanded and are necessary if accurate data are to be obtained. In dynamic procedures, however, when normally both eyes are fixating, if possible, in a condition of binocular single vision, the object under regard, by reason of the stimulus to binocular single vision as supplied by the accommodative or fusional convergence source (or more generally by both of these sources) and when both eyes are endeavoring to read at close range a chart or card of printed material, there is produced a definite and probably maximal stimulation to the development of the necessary accommodative changes. Obviously it is possible that certain pairs of eyes may be unable to develop the requisite amount of accommodative change, either on account of changes in the condition of the crystalline lenses of the eyes or by reason of insufficiency of ciliary innervation or action. In such a condition plus (convex) lenses will be needed to supply the accommodative insufficiency. Again, other pairs of eyes may develop excessive accommodative changes or excessive ciliary innervation, in which case plus (convex) lenses may be needed to inhibit or suppress the accommodation.

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Ordinarily it is taught, and correctly so from theoretic principles, that an algebraic deduction of one diopter should be made in the static skiametric findings as an allowance for the optical equivalence of a working distance of 1 meter. For instance, a neutral shadow obtained with a +5.00 D.S. with a working distance of 1 meter would be presumed to indicate hyperopia of 4 diopters. The statement is made by Alger, in *The refraction and motility of the eye*, and doubtless by other writers, that, when working at 1 meter and without a cycloplegic agent, the skiametric findings which indicate a neutral shadow at that distance should be recorded as the correct findings, allowance not being made for the working distance. While I cannot accept this statement as a fact, I do believe that there is in practically every case refracted without cycloplegic agents a marked tendency toward undercorrection in hyperopia and overcorrection in myopia. In static skiametric procedures I have, therefore, for years worked at from 65 to 75 centimeters and made an allowance of 1 diopter only (instead of the theoretic value of 1.5 diopters) for the working distance and have found that the skiametric findings thus obtained approximate closely the binocular prescription finally determined in the majority of eyes in which decided abnormalities are not present in the extrinsic ocular muscles or accommodative resources.

In dynamic skiametry allowance is not made for the working distance provided the point of fixation on the part of the subject under test and the point from which observations regarding the shadow movements as made by the examiner are one and the same or in close proximity and in the same plane. It is highly desirable that the angle between the observed and observing eyes shall be as small as possible, since it is a well-known fact that oblique incidence in skiametric procedures gives the same astigmatic effects as are produced by the tilting of any lens or lens system. The technic of dynamic skiametry should ensure fixed and active attention on the part of the person under test, thereby stimulating accommodation and convergence.

The Theory of Cross

Dynamic skiametry, therefore, is an objective method of ocular examination first introduced into the routine of refraction by Andrew Jay Cross[4] in 1902 for measuring the refraction of the eye by means of shadow testing when the accommodation is actively stimulated.

The theory and practice as conceived by Cross were based on two premises:

1. That a muscle in action and abnormally taxed or burdened will accept assistance more readily than a muscle at rest and when normally innervated and normally functioning.

2. That accommodation and convergence are normally related

in a more or less fixed ratio (usually stated as 3:1) and that, if accommodation is correlated with the convergence in that ratio, the eyes will maintain that ratio and will not exhibit further relaxation of accommodation which would break the ideal relationship between accommodation and convergence.

The Theory of Sheard

In 1917 I[22] presented my opinions on the significance and value of dynamic skiametry. I later added further proof in support of my contentions and suggested a lag of accommodation behind convergence by way of explanation of certain differences between static and dynamic skiametric findings which consistently occur in eyes as nearly normal in their accommodative and convergence functions as can be found[23]. My chief criticisms to the theory of Cross are:

1. It assumes that convergence is wholly stimulated by accommodation: that is, that the convergence necessary for binocular single vision is normally produced centrally or in accompaniment with the act of accommodation.

2. It fails to consider the findings obtained by dynamic skiametry, when plus lenses are added until a reversal of shadows occurs, as objective measurements on the so-called negative range of relative accommodation.

3. Clinical experience has demonstrated time and again that latent hyperopia does not develop when correcting lenses have been prescribed for constant wear in accordance with the findings of dynamic skiametry when carried to the point of reversal. In brief, lenses prescribed in rigid adherence to the theory of Cross could not be tolerated and worn.

Sources of Convergence

The relative accommodation-convergence tests, as obtained by the subjective method described by Donders[5] in 1864 in his classic treatise, indicate that there is some dependence and some independence of the functions of accommodation and convergence.

There are two sources of convergence available for obtaining binocular single vision: accommodative and fusional or supplementary. By dissociation tests, made through the use of prisms base up and down respectively before each eye (or preferably through the use of a sufficient amount of prism, base down, before the nondominant eye) binocular single vision can be prevented and the amount of convergence associated with the act of accommodation (that is, accommodative convergence) at any distance of fixation can be determined. The difference between the amount of convergence demanded mathematically at any point (the Prentice rule) and the accommodative convergence developed at that point, due regard being given to the extrinsic muscular balance at 6 meters, is a measure of fusional or supplementary convergence at that point. The amounts of accommodative convergence vary greatly in differ-

ent individuals: it may be nil (assuming orthophoria at distance) as one extreme and, as the other extreme, there may be any amount of overconvergence associated with the act of accommodation. It is not possible, therefore, to determine through what channels the act of binocular single vision is accomplished unless it is determined analytically. The relationship of convergence and accommodation in binocular single vision may be, then, approximately 3:1 but all of the convergence may come through the innervation associated with the accommodative channels and none through the fusional stimulation in one pair of eyes, whereas, in a second instance, none may come through the accommodative channels and all convergence needed be supplied through innnervation from the supplementary or fusional sources. As a result, the dependence and independence of accommodation and convergence must rest, in part at least, on the manner in which binocular single vision is produced. It is for this reason, as well as by virtue of other arguments to be presented, that I do not believe that the dynamic skiametric finding obtained at any fixation point (observation and fixation being the same distance), when reversal of shadows is obtained, is a measure of the accommodative assistance required to correlate accommodation and convergence, but may be taken to be a measure of that which Donders termed the negative relative accommodation evidenced under the conditions of singleness of vision (or convergence) which obtain in the eyes under examination, irrespective of the source or sources of innervation.

If dynamic skiametry, however, as outlined and practiced by Cross, is an objective method of finding the negative portion of the relative range of accommodation, it is of definite value. For Donders[5] stated the important principle: "The accommodation can be maintained for a distance at which, in reference to the negative part, the positive part of the relative range of accommodation is tolerably great."

Dynamic Skiametry as a Possible Objective Test of Relative Accommodation

The contention that dynamic skiametry, as developed by Cross and practiced with the use of fixational and observational distances the same and lenses added until reversal occurs, is simply an objective method of determining the negative relative accommodation is substantiated by the following citations from Cross[4]:

"Case 1.—Age of patient, twenty years. Fixation, 40 inches. Observation, 39 inches. Shadow with the mirror. Can add + 1 diopter before reversal occurs. But with fixation and observation at 10 inches, a total of + 1.50 diopter can be added before reversal takes place. The same result is obtained when fixation and observation are at 13 inches.

"Case 2.—Age of patient, thirty years. Fixation, 40 inches. Observation, 39 inches. Shadow shows against the mirror. Reversal

takes place at 20 inches, which, after deducting 1 diopter for the accommodative myopia at 40 inches, leaves 1 diopter of true myopia. Subjective tests call for a — 1.50 D.S. lens. Fixation and observation at 16 inches show a 'with' motion with a — 0.75 D.S. lens and at 13 inches a — 0.50 D.S. lens is the weakest one with which a 'with' motion can be obtained."

Hence the dynamic skiametric findings vary under the procedure of obtaining reversal of shadows at various distances of equal fixation and observation and constitute fundamentally a means of obtaining relative accommodation and are not indicators, per se, of the lenticular assistance demanded in order that the accommodative demands or, again, the proper co-ordination between accommodation and convergence may be met.

Bestor[3] also claims that dynamic skiametric findings, obtained at an equal fixation-observation distance of 33 centimeters, when carried to the point of reversal gives values from 1 diopter to 2 diopters (average about 1.5 diopters) greater than the static skiascopic findings. He believes, however, that the theory of Cross is correct. Bestor writes:

"The amount of hyperopia developed in an emmetrope of forty-five years of age or more, as indicated by the graph after Donders, reaches an average total of about 1.50 diopters. Coincidentally this is about the average difference found between dynamic skiametric and subjective findings. So consistently does the average prove true in practice that the writer usually commences his subjective examination by making an arbitrary deduction of + 1.50 D.S. from the findings obtained dynamically and if there is much variance, he is led to an investigation of the tonic and dynamic muscular conditions of the eyes for causes that may have made the dynamic findings faulty."

Lag of Accommodation Behind the Point of Fixation

In 1920[23] I published the statement: "I feel rather positive from a long series of tests by various methods of skiametric testing that there is always a lag, skiametrically considered at least, of the accommodation behind the convergence." In other words, that eyes practically emmetropic so far as any static or subjective tests could determine, possessed of plentiful amplitude of accommodation, fusion powers and reserves ample (or as nearly physiologically perfect eyes as could be found) have demonstrated that small convex lens quantities are accepted skiametrically, fixation and observation being in the same plane and at close range to the observed eyes. The values of these convex lens quantities remain approximately the same irrespective of the distance of fixation provided this distance is a relatively short one (tests actually made within the range of 20 to 50 centimeters) and amount to practically 0.5 to 0.75 diopter before neutrality of shadows is obtained. Another method of testing is to take an emmetropic pair of eyes and have them fix a small letter on

a quarter or half inch card attached to a suitable support and thus to determine the point of neutral shadow skiametrically. In such emmetropic eyes, or those which have been rendered so artificially, so far as refractive errors are concerned, it is found that the point of neutral shadow is slightly farther from the subject's eyes than the point of fixation, irrespective of the position of this point. The practical result of this state of affairs, is that all dynamic findings will be slightly greater at close points in hyperopia and slightly less at corresponding distances in myopia than the static retinoscopic findings. This phenomenon I have designated as a normal lag of accommodation.

Technic of Dynamic Skiametry as Proposed by Sheard

In various articles and books I have stated that I advocate the use of dynamic skiametry, as a general rule, with observation and fixation (which also implies an attempt at focusing the test-object used as an object of fixation) at the point demonstrated by the person under test to be the usual reading or working distance and then proceed to determine the values of the lens quantities necessary to produce neutrality of shadows[28]. Initially there are obtained by monocular static skiametric methods those refractive findings which put each eye, in turn, in such a condition, optically considered, that the retina and the distant point of fixation, passively fixated, are conjugate after due allowance has been made for the working distance. All spherical lenses used, including, therefore, both the lenses dioptrically equivalent to the working distance and the lenses representing the static refractive error, are left before the eyes and the subject's attention is directed to a small card of printed material attached to the mirror. The cylindrical lenses used in the static refraction are removed, since it occasionally happens that there is a difference between the axes and amounts of cylindrical corrections determined by the static and dynamic methods. The subject is then instructed to read or to attempt to read the letters or count the dots on the chart used for fixation and focusing purposes. The direction of movement of the shadow is quickly noted in each eye and such spherical and cylindrical changes made as will afford the *first evidence of neutral shadow* in all meridians.

As a matter of routine, an equal fixational-observational distance of 33 centimeters is taken. Findings at other distances of equal fixation and observation may be taken if desired, but experience indicates that little if any data of additional value will be obtained. Since it is my belief that static retinoscopic findings are more accurate if the working distance is about 75 centimeters (theoretically equivalent to 1.37 dopters) and an allowance of 1 diopter only is made, and since experience has shown that there is that which I have termed a lag of accommodation, amounting to about 0.5 to 0.75 diopter at the 33 centimeter equal fixational-observational distance, I interpret a neutral dynamic skiametric finding at the distance of

33 centimeters obtained with the total quantity of lens used in the static retinoscopic determination in place before the eyes, as indicative of three probable conclusions: (1) the static retinoscopic findings are approximately correct, (2) these findings will be satisfactory for both distant and close vision, and (3) the relationships between accommodation and convergence are normal. I believe that normally the dynamic skiametric findings, with observation and fixation at about a distance of 33 centimeters, will exceed the static retinoscopic findings by about 0.75 diopter. If the dynamic findings, as determined from the lenses which produce the first indication of a neutral shadow, exceed the static retinoscopic determinations by more than 0.75 diopter in either emmetropia or hyperopia or are decreased by more than a like amount in myopia, there is objective evidence of one or more of the following conditions: (1) undercorrection of hyperopia or overcorrection of myopia by static methods, (2) spasm of accommodation, (3) subnormal or inefficient accommodation, (4) presbyopia, and (5) marked defects of the extrinsic muscular co-ordination, interfering with the normal functioning of accommodation and binocular single vision.

Difference Between Neutral and Reversed Shadows in Dynamic Skiametry

It is doubtful if the real value of dynamic skiametry in the routine of practical ocular refraction is appreciated if it is regarded solely as a possible objective method of getting the so-called negative relative accommodation. This statement is made in full cognizance of the possible service which dynamic skiametry may render in affording data on the relative accommodation-convergence relationships existing in any particular pair of eyes under examination. And again, this statement is made in the face of the acceptance of the foregoing viewpoint on the part of many others and as voiced by Atkinson and Woll[2], for example, when they write: "Another group, instigated and headed by Charles Sheard, believes that dynamic skiametry as taught by Cross is principally a quick and sufficiently accurate method of determining the negative relative accommodation of the eyes, that is, the range of accommodation they can be forced to surrender without changing the convergence. From such a viewpoint dynamic skiametry assumes the highest practical value. It becomes an excellent method of determining the reserve accommodative power of the eyes and the flexibility of the functions of accommodation and convergence, and it also affords a means, as Cross held, of finding the point at which accommodation and convergence are most normally and comfortably related."

I believe that the value of dynamic skiametry lies in the fact that, when practiced after the manner which I have described as being my modification of the original method of Cross, it can be used to determine objectively the character and amount of the accommodative needs, whether these are of a nature demanding

auxiliary assistance, relaxation, or innervational suppression. It seems to me that data on the accommodative needs can be obtained quite accurately if the findings which give *the first indication of a neutral shadow* are taken and recorded, due allowance also being made for about 0.75 diopter of so-called lag of accommodation except in cases of advanced presbyopia. From this statement the inference is drawn correctly that there is a range of neutral shadow skiametrically existent between the point of initial neutrality of shadow and reversal of shadow.

Many skiametrists report difficulty in the matter of judging when a condition of neutral shadow is present and many have written stating that they find a considerable range of lenses which afford neutral shadows. Such an observation is, I believe, correct. Reference has been made to this situation in the preceding paragraph. The point to be emphasized is that, according to my theories and explanations, the *initial condition of neutral shadow* only is to be regarded in routine refraction.

Fixation and Observation at One Meter as Advocated by Petry

Ernest Petry [*] has been an ardent advocate of the use of dynamic skiametry with fixation and observation at a distance of 1 meter. Since I know of no articles in the literature which present an account of his method, I am reproducing a personal communication from him.

"Since the primary purpose of dynamic skiametry is to determine the refractive condition of a pair of eyes during their binocular functioning status, and since it is a well known fact that variables are found in the co-ordinations of accommodation and convergence at different distances of application, and also as applied to different individuals at the same distances, it seems practical to select a degree of binocular application in which a minimum of variables will be manifested.

"To merely make the statement that the variables are decreased when dynamic skiametry is applied at approximately 40 inches or 1 meter is insufficient to establish it as a premise. There are four apparently sound reasons why dynamic skiametric findings based on the neutralization arrived at with the least plus or minus lens power when fixation by the patient and observation by the examiner are established approximately 40 inches or 1 meter.

"The first reason is that the interpretations of the motions and the striations of the reflex are easier to arrive at when the distance between the examiner and the patient is as great as will barely permit the seeing of the reflex. This is substantiated by the simple experiment of taking a low-powered lens and moving it laterally before the eyes while viewing the apparent motions of the image

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of the object through it. With the lens at close range to the observing eyes, the motion is much more difficult to determine than when the lens is held at arms length.

"The second reason has to do with the physiological resistance offered to correlation of the accommodative and convergence functions of an ametropic eye. It seems reasonable to assume that when the convergence function is called upon to exert itself to the maximum required by an average individual for any application of his eyes, the strain thus encountered causes a resistance to a continuous accommodative application and produces a negative relative accommodative tendency. Therefore, since the fixation at approximately 1 meter constitutes an average application, this resistance is minimized.

"Thirdly, the psychological influence to allow the fixation and accommodation to straddle the object of regard whenever the mental requirement is thus satisfied produces an involuntary tendency on the part of the ametropes to so apply their eyes when the object of regard is relatively large. Therefore since the fixation objects on dynamic skiascopes are for the most part of a size that requires definite fixation only when applied at a distance of approximately 1 meter, the use of such targets at closer range injects the uncertain element of mental satisfaction. In other words the fixation and focusing elements will be adjusted in such cases with the minimum effort, and this establishes a satisfying mental status. When these targets are applied at the 1 meter range a more definite fixation is required and less indefinite focusing will be tolerated.

"The fourth reason for the claim for greater accuracy in the determined refractive error when dynamic skiametry is applied at approximately 1 meter is that of lens effectivity which causes the ratio of the effectiveness of accommodation to decrease when near objects are viewed through plus lenses and increase when minus lenses are utilized.

"The increase of plus power and decrease in minus power introduced for the reasons cited in the foregoing paragraphs, together with the greater difficulty presented in the analysis of the reflex movements when fixation and observations are established at the 33.3 centimeters distance (since these are minimized when a greater distance is employed) seem to indicate that if dynamic skiametry is to be used for the purpose of determining the refractive condition of a pair of eyes, it should be applied at the greatest distance which is convenient and which still is such as to require a moderate binocular functioning."

Modifications and Interpretations of Tait

Edwin F. Tait* has been conducting a series of researches involving dynamic skiametric findings and their correlation with other

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data regarding convergence and accommodation. He has devised a skiascope which is an improvement over the designs of Cross, Sheard and Ryer in that it permits the examiner to obtain data quickly and accurately with observation and fixation as nearly along the visual axis as is possible practically.

At the time of the preparation of this paper the results of Tait's investigations have not been published and I am limited, therefore, in the possible accuracy of presentation of his ideas as well as laying myself liable to incorrect emphasis. Tait's fundamental premise is that there is no accommodative convergence unless there is accommodation. Employing the method of obtaining and recording dynamic skiametric findings which involves procedure to a definite reversal of shadow, Tait has tabulated the relationships between the exophoria at the distance of fixation, the accommodative convergence and the allowance (that is, the amount which may be deducted algebraically from the dynamic skiametric findings) which is to be made for distances of fixation and observation of 33.3 centimeters and 20 centimeters.

EXOPHORIA (Prism diopters)	ACCOMMODATIVE CONVERGENCE (Prism diopters)	ALLOWANCE IN DYNAMIC FINDINGS	
		33.3 cm.	20 cm.
6	12	1.5	2.00
8	10	1.75	2.50
10	8	2.00	3.00
12	6	2.25	3.50
14	4	2.50	4.00
16	2	2.75	4.50
18	0	3.00	5.00

Tait has also obtained important data regarding the relationships of lenticular tonicity, lag of accommodation and age. His results have accrued from a long series of data acquired in the examination of over a thousand pairs of eyes of all ages and conditions of refractive and extra-ocular muscle errors. In youth the average lenticular tonicity amounts to about 1.0 to 1.25 diopters; at thirty years of age, to about a 0.5 to 0.75 diopter and from forty years on to approximately 0.25 diopter. In other words, the tonicity decreases approximately logarithmically when plotted against the age, hence the percentage loss or rate of loss of tonicity is practically constant. On the other hand, the lag of accommodation is very small in amount in youth and of the order of 0.25 diopter. At thirty years of age it reaches a value of 0.75 diopter and in old age (presbyopic stage of sixty years and beyond) approximates, for the 33.3 centimeters fixation distance, the value of 3 diopters. At thirty years of age, therefore, the tonicity and lag of accommodation each amount to 0.75 diopter. This substantiates the assertion of Sheard that the average lag of accommodation prior to the presbyopic state amounts to about 0.5 to 0.75 diopter. The sum of the values of the tonicity and lag of accommodation at thirty years of age amounts

to practically 1.5 diopters. If, then, the dynamic skiametric findings are made by the methods of reversal, as originally advocated by Cross, an average allowance of 1.5 diopters should be made. In toto, these results of Tait, should they be substantiated, will do much to clarify the field of dynamic skiametry.

Dynamic Skiametric Measurements of the Amplitude of Accommodation

Whether or not dynamic skiametry is to be accepted as a method of much or little value will depend ultimately on the results of researches on relative accommodation, relative convergence, monocular aberrations, effects of pupillary contraction and other phenomena of a dynamic character. At the present time I believe dynamic skiametry affords information, quickly obtained and reasonably accurate, regarding the accommodative needs of the eyes under examination. The method is essentially a near-point test; it is of service in that it affords evidence objectively regarding presbyopia, subnormal or inefficient accommodation, astigmatic corrections at the reading distance and may furnish clues to and partial solutions of latency of hyperopia, spasm of accommodation and interference of extrinsic ocular imbalances with normal accommodative action.

The investigations of Cross and others regarding dynamic skiametry in both theory and practice may be accepted or rejected in whole or in part. But I believe that these discussions regarding dynamic skiametry have given us certain objective tests which we should not have had, in all probability, but for dynamic skiametry. Chief of these tests are those which have to do with objective measurements on the monocular and binocular amplitudes of accommodation. Such methods disclose conditions of marked anisometropia (such as hyperopia in one eye and myopia in the other eye), and furnish information as to the part which each eye plays in distant and close vision.

In 1917 I[22] presented an application of dynamic skiametry for purposes of measuring the amplitude and range of accommodation by determining the near point of the eye under examination. Theoretically, this is the closest point for which an eye is capable of accommodating and therefore the closest point at which a neutral shadow or reflex can be obtained. By reason of the presence of the so-called lag of accommodation and other practical difficulties which may arise, I have advocated the practice of approaching an object closer and closer to the eye, following it with the skiascope, until a point is finally found such that closer approach of the test object to the eye does not change the neutral condition of the reflex as skiascopically seen by the examiner's eye at the closest point at which a neutral reflex is obtained. In testing for the near point objectively the procedure is as follows: The subject under test draws the test-object (which may be a vertical row of letters from 0.12 to 0.25 inch in width, mounted on a suitable holder) as near the eye as will still

permit of its being read easily. To the observer (skiametrist) who is situated several centimeters beyond the test-object, the skiascopic reflex will show an "against" or myopic condition indicating that he is outside of the point which is optically conjugate to the observing eye. The examiner then moves forward until he obtains the position of neutral shadow. Then the test-object is to be carried still closer to the eye and the nearest point of neutral shadow found and measured. The report of inability to see distinctly or blurring on the part of the person under the test is of no importance; the attempt to read and decipher, however, is vital since the maximal exertion of accommodation is desired. The measurement of the distance between the nearest point of neutral reflex and the eye under test gives the apparent near-point and hence amplitude of accommodation under the ocular conditions prevailing during the test (ordinarily when the distance corrections are worn).

The determination of the binocular amplitude of accommodation by dynamic skiametry is fundamentally the same as in the monocular procedure. In the binocular test both eyes, if possible, are fixating the vertical row of test letters. The examiner can determine the neutral point for each eye at any given position of the fixated object and can ascertain whether the binocular amplitude is less than, equal to, or greater than the monocular amplitude. Furthermore, both by monocular and binocular tests, he can acquire data regarding the equality or inequality of accommodative amplitude.

These objective or skiametric methods of obtaining data regarding accommodation immediately suggest themselves to be of value in finding the range and amplitude of accommodation in children and illiterates; in conditions of presbyopia, subnormal accommodation, inequality of accommodation and in amblyopia, when the examiner may be uncertain whether or not accommodation is still active because of the uncertainty of subjective tests by reason of the reduced visual acuity.

Duane[6] carried out some very careful investigations on monocular and binocular amplitudes of accommodation using a subjective method and arrived at some important conclusions: "(1) The binocular amplitude of accommodation will be regularly higher than the monocular value. (2) The binocular exceeds the monocular by amounts varying from 0.25 to 1 diopter. (3) When the monocular value exceeds that of the binocular, we may be sure of muscular imbalance. (4) The accommodative surplus in binocular vision is apparently due to a convergence action which induces an extra accommodative effort which is impossible when one is not converging binocularly. In monocular accommodation there is evidently a certain degree of inertia which must be situated in the ciliary muscle and which we may call the *physiologic accommodation.*" These conclusions regarding amplitudes of accommodation, obtained sub-

jectively, possibly throw some light on the dynamic skiametric data and their interpretation.

The great ocular problem is the economic co-ordination of accommodation and convergence. To this end information should be acquired in as many ways and by as many methods as possible, with a realization that every method and test has its inherent sources of error. The category of fundamental tests should include examinations by ophthalmoscopy, ophthalmometry static retinoscopy, dynamic skiametry, subjective acuity tests, extrinsic ocular tests at 6 meters and the reading distance, amplitudes of accommodation and duction tests on the extrinsic muscles with fixation at 6 meters and 33 centimeters respectively. In other words, all data possible should be obtained regarding the eyes when in a static or passive condition and when dynamically functioning in the act (actual or attempted) of distinct and binocular single vision.

In conclusion, by reason of the limited amount of space in which to fully present and discuss the subject of dynamic skiametry in all its aspects, I have been compelled to omit references to the work of Bestor, Southall, Nott, Prentice, Atkinson, Woll, Ames, Gliddon, McFadden, Pascal, Laurance and others. The bibliography contains a list of authors and the articles which they have contributed on the subject of dynamic skiametry and topics germane thereto.

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A QUESTIONNAIRE ON THE ASSOCIATED FUNCTIONS OF CONVERGENCE ACCOMMODATION AND FUSION

In the effort to broaden our understanding of the associated functions of convergence and accommodation the following questions were sent to Dr. R. M. Peckham and several other men whose outstanding work in ocular myology makes their views on these matters of the utmost importance and we believe of the greatest interest at this time. We will publish in subsequent issues the views on these questions, of other of our practitioners.

The questions are as follows:

What is the relation between esophoria (excessive convergence) at the near point in the young adult and high exophoria (convergence lag) in the presbyope?

Is the one the forerunner of the other? That is, can we expect the young adult with excessive convergence at the near to have convergence lag of high amount at the near when he becomes a presbyope?

If not, why is it, that convergence excess at the near is the common imbalance found in the young while convergence lag is usually associated with the presbyopic period. Why is it, that the percentage of convergence excess cases found among young patients dovetails with the precentage of convergence lag cases found in the older ones? Why is it, that the young patient who shows a convergence excess is as a rule the ardent, energetic, "doer" type and this also holds true of the average presbyope who shows a convergence lag? Are these facts mere coincidence or do they point to the fact that convergence excess at the near in the young adult presages convergence lag in the prebyope?

If it can be demonstrated that the convergence excess of the young adult turns into the convergence lag of the older patient, what is to be done about it?

We know that uncorrected hyperopia, hyperopic astigmia, over corrections of minus, prism power base-out, wide interpupillaries and pathology cause excessive convergence. What other factors are causative?

Does a convergence excess at the near always keep company with a faulty, incomplete, or imperfect fusion sense?

If so, is it this lack of positive binocular fixation or anchorage, associated with faulty fusion, which permits the development of a

convergence lag when the accommodation no longer functions unaided at the near point?

Further, what factors contribute toward the conversion of a convergence excess into a convergence lag? We know that over-corrections of plus, especially reading corrections for presbyopes, and base-in prism power gradually bring about convergence relaxation, which can result in a convergence lag. What other factors produce this result? Do small segment bifocals tend to cause convergence lag by the disturbing effect they may have or near point fixation? Are large segments, conducive to easier near point vision when there is a convergence lag present?

If prism power base-in only tends to convert one distressing condition (convergence excess) into another (convergence lag) over a period of years, is it not questionable procedure to use such prism power either for wear or exercise without close and constant supervision of the case? Should not the use of such procedure always be accompanied by fusion training?

Is correction of a faulty fusion sense the surest and sanest way to establish comfortable ocular balance? If so, should not all orthoptic training stress the development of greater fusion power?

These questions are asked with the view of clearing up the haze surrounding the whole question of ocular imbalances. We believe that the group mind of our leading optometrists can solve the problems of ocular balance and set our feet upon the pathway of clarity and established facts.

Dr. R. M. Peckham reviews the above questionnaire and comments thereon in the pages immediately following. For the reader's convenience the following Reference List of previously published manuscripts in answer to this questionnaire is given:

Convergence, Accommodation and Fusion. Dr. I. S. Nott, American Journal of Optometry. Vol. 6, No. 1, pp. 19-29. 1929.

Convergence, Accommodation and Fusion. Dr. J. I. Pascal. American Journal of Optometry. Vol. 6, No. 2, pp. 102-104. 1929.

Convergence, Accommodation and Fusion. Dr. M. Steinfeld. American Journal of Optometry. Vol. 6, No. 3, pp. 169-171. 1929.

Convergence, Accommodation and Fusion. Dr. W. Bagwell. American Journal of Optometry. Vol. 6, No. 3, pp. 193-194. 1929.

Convergence, Accommodation and Fusion. Dr. A. E. Hoare. American Journal of Optometry. Vol. 6, No. 7, pp. 401-405. 1929.

CONVERGENCE, ACCOMMODATION AND FUSION*

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Dr. Pascal's discussion of this questionnaire in the February, 1929, issue of this Journal is, without doubt, a most valuable contribution, particularly at this time, when we are questioning practically all of the traditional theory that has grown up, much like the myths of the ancients, around the various phases of our work and our contact with the problems of eye strain.

For Dr. Pascal points very clearly to the fact that the tonicity of the body, high in youth, decreasing with advancing age, and also the development of hypertonicity with subsequent fall to hypotonicity in any heavily worked group of muscles, is the real foundation of the phenomena of esophoria and exophoria with latent hyperopia.

To this may be justly added the so-called "spasm of accommodation" linked with latent hyperopia in youth, and the falsely denominated "lag of accommodation behind convergence," phases of toncity that opticists have erroneously attempted to interpret in optical terms as phases of accommodation as an independent function.

In this connection we are reminded of Dr. Pascal's discussions at the A. O. A. convention in Indianapolis some years ago. There Dr. Pascal called attention to the fallacious reasoning behind the theories of "fusional reserves." But at that time he was so far ahead of the rest of us that we failed to appreciate the unassailable logic of his position. His approach from the firm foundation of physiology and physiological psychology, both at that time and in this recent paper, is the point from which we must start if we are to avoid the pitfalls into which our predecessors have fallen. While the writer might not use exactly the same terms as Dr. Pascal has employed, he is in hearty agreement with the larger part of his paper. We should enjoy some paragraphs from him as to these various assumptions in the questionnaire, which he allows to pass without discussion.

Dr. Hoare's presentation of the problem as one of tonicity, rather than as of some abstruse, metaphysical postulate, is lucid and logical. His suggestion that in esophoria the cause of the relative hypertonicity of the convergence muscles may be in fact a relative hypotonicity of the abducens muscles because of exhaustion, is novel. But there is an idea well worth laboratory investigation.

In this questionnaire, it would seem that its author has made

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some effort to bring to our attention many of the fallacies of our traditional definitions and theories. Also, by associated suggestion, he has brought to mind several that he has not directly mentioned. He has included some intimations of some of the later ideas that have appeared in the more recent years. Also, he has presented several assumptions that seem unwarranted. Assumptions and terms, as presented, are not always in agreement. Such presentation seems of distinct value, for we are thereby driven to careful consideration, to downright questioning, as to what we really mean by some of the terms we employ quite freely, as to the validity of some of our assumptions, as to the correctness of some of our definitions.

For instance, we have the mistaken use of the word "esophoria" as synonymous with "convergence excess," the wrong definition of "exophoria" as "convergence lag." Whether these are the definitions understood by the author of the questionnaire is not apparent, and is beside the point. They are definitions that came into use some time ago, but are not the definitions originally given by the coiners of the terms "esophoria" and "exophoria." But we have them, though most of us realize the error, and they are still in current use by certain groups.

The idea that esophoria is, in itself, "convergence excess" is a relic of the unsound theories concerning the relations of convergence and accommodation with which we have been afflicted so many years; the earlier theory that "accommodation controls convergence," which proved an unsound and unworkable hypothesis; the later theory that "convergence carries accommodation," workable but shown equally unsound from our present studies of physiological psychology. These theories were based on the medieval psychology of "mental faculties," a viewpoint abandoned by the experimental psychologist of this generation who wisely rejects the metaphysics of his predecessor.

Rather, we look at esophoria as an indication of hypertonicity of the convergence muscles; in cases of latent hyperopia, here under consideration, developed in the ardent desire of the energetic youth to gain clear vision, and not to be considered by itself but in its relations with other hypertonicities arising in the same reflex arcs. For at the same time, we find hypertonicities in the accommodative muscles, wrongly called "Spasm of the Accommodation," only to be combatted by atropine or base-in prisms. Also, a hypertonicity of the sphincters of the irides, apparent as contracted pupils, which is inhibited only by atropine or base-in prisms. Fogging lenses, advocated by the supporters of the "accommodative-convergence" theories have been proved utterly inadequate for the checking of these hypertonicities, save in a comparatively few cases of hypertonicity about to develop into the hypotonicity of exhaustion.

These three hypertonicities, of convergence muscles, accommodative muscles and pupillary contracting muscles, are evidently but

simultaneous, or synergistic, end organ evidences of the strongly innervated visual attention reflex arcs, aroused in that keen interest in his environment displayed by the eager, ambitious youth of "the doer type." For it is only in the young of this psychological bent that we find our latent hyperopes with esophoria. In this matter we agree with the author of the questionnaire.

The present day definition of orthophoria, as given in several medical dictionaries is: "A state of balanced tension, or tonicity, of the extrinsic ocular muscles." To this we may add, with Maddox in his latter day writings: "Such that the visual axes tend to remain in their position of use." This is quite different from the old definitions with their terms of "structural perfection," "parallelism of the visual axes," "convergence-accommodation balance," and so on.

Then we have the corollary of esophoria as an indication of hypertonicity of the convergence muscles, and exophoria as a showing of hypotonicity of these muscles, remembering that all things are relative, that hypertonicity of one muscle or group of muscles means a proportionate hypotonicity of the antagonists, and the reverse. These interpretations are in accord with the laws of reciprocal innervations and tonicity.

In youth, and sometimes in adults who retain unimpaired the vigor and tonicity of youth, our dynamic skiametry findings reveal a hypertonicity of the accommodative muscles directly comparable and proportionate with the esophoria found at the near point. In this connection we would call the reader's attention to the value of noting the physiological exophoria, that is, the difference between distant and near phorias when the same technic, or method, is employed in taking both measurements. (If the distant phoria is taken by one method and the near phoria measured by another method, the comparison is valueless, since so many factors, physiological and psychic, enter the problem.)

A physiological exophoria of 6$^{\Delta}$ has been accepted as the normal. Bear in mind, that physiological exophoria is the difference between distance and near phorias. The amount of exophoria found at the near working point is not the physiological exophoria, as is erroneously taught in some of our schools. The amount of exophoria shown at near is exactly what it is, the near point exophoria. The difference between the amount found at distance and the amount found at near is denominated the "physiological exophoria." It seems to the writer that the study of the physiological exophoria is of far greater importance than the attention that has been given in the past to either distance or near phoria. But I should hesitate to accept a flat amount as "normal." Rather, it seems wiser to allow a little latitude, and, from a careful study of records we may accept a standard of the normal expectation of the physiological exophoria as varying from 4$^{\Delta}$ to 6$^{\Delta}$.

Series of phoria tests taken of a group of students, ages from

18 to 25, over a period of several weeks shows that the amount of esophoria or exophoria varies greatly, not only from day to day but from hour to hour, depending on the bodily tonicity at the time, that is, whether the subject is rested or fatigued, and also on the psychic state, whether the subject is under the influence of some highly stimulative emotion, some exhaustive emotion, or is in a balanced emotional state. More than this, most of the subjects showing esophoria at one time, showed exophoria at another. But though the phoria itself showed considerable variation in degree and kind, the physiological exophoria, or comparison of distance and near phorias, remained fairly constant in each subject, within a latitude of 4$^{\Delta}$ to 6$^{\Delta}$. We might note, here, and it is an interesting comment on the present discussion, that both degree and kind of phoria varied greatly by different test methods.

A physiological exophoria of less than 4$^{\Delta}$ is to be interpreted as a near point esophoria, or negative physiological exophoria.

The writer has pointed out, in other papers, that there is an esophoria, frequently with a negative physiological exophoria, of psychic origin, due to excitement, or excessive mental stimulation, and without latent hyperopia. Mention of this is in place here, since we shall refer to it later under the discussion of a questionable statement in the third paragraph of the questionnaire.

Now, we find a high physiological exophoria in adult latent hyperopes who have become exhausted, or worn out, by the efforts sustained through many years of compensation of their structural hyperopia. This high physiological exophoria reduces, usually at once, when the full plus requirement is supplied. Oddly enough, quite frequently the physiological exophoria is increased when only a partial correction is given, then decreases when we give the full plus needed to inhibit over exertion.

We also find that these adult latent hyperopes will frequently show esophoria at distance and a low physiological exophoria in the morning, when rested, while late in the afternoon, if they have spent the day doing close work, they will invariably show a high physiological exophoria and may show an exophoria at distance. Such exophoria I should term "exhaustion exophoria."

We find the same story of high or low tonicity in our comparisons of static and dynamic skiametry. I have observed that in the type of youth we might call "normal" that there is a "lag" shown in the dynamic of about 3 D. Sph. at the age of 4 and that this "lag," or difference between static and dynamic findings grows less as the visual attention reflexes mature, until at the age of 30 it is about 0.50 D. and at the age of the onset of presbyopia, about 38 to 40 this "lag" decreases to zero.

This is not properly termed "a lag of accommodation behind convergence," as some have termed it, but is what we might term "a lag

of tonicity," comparable in every way, following the same biological laws, as physiological exophoria.

The child who starts out in very early life with an unquenchable desire for clear vision, who masters the problem of the visual attention reflex arcs, who attains the normal 20/XX or 20/XV vision at a precocious age, in the phoria test shows a low, or negative, physiological exophoria and at the same time an abnormally low "tonicity lag" in dynamic skiametry. That is, instead of finding, in such cases, a physiological exophoria of from 4Δ to 6Δ, we find only 1Δ or 2Δ, or we may find none, or we may find more esophoria (or less exophoria) at near than at distance. At the same time, and by the same token, we find his dynamic skiametry about the same, and sometimes less than, the static skiametry.

On the contrary, in the youth who "does not bother" to focus, who does not develop normally the visual attention reflex pathways, we find a higher degree of physiological exophoria than our expected 4Δ to 6Δ and we find a proportionately higher "tonicity lag" than the expected amount for his age.

In adults of this type, we also find the same story of high physiological exophoria and the same high tonicity lag in skiametry. These adults are usually "absolute hyperopes"; that is, they need plus lenses for clear distant vision.

We might distinguish this type of exophoria and tonicity lag as of "afferent origin." By which we would infer that tonicity is not normally developed because of the lack of habitual response to the sensory impulses, the individual being of a lackadaisical nature in whom the desire for clear vision is not the obsession that it is with the latent hyperope.

Tait has shown that there is a normal numerical relation between high physiological exophoria and high tonicity lag. But the writer has found many exceptions to this rule, mainly in cases of the neurotic type.

Unfortunately for our peace of mind, we find that the exhausted latent hyperope and this type of habitual low tonicity just described, show much the same findings as to phoria tests and skiametric measurements. But whereas we must not give all the plus found in skiamtry to the patient of low tonicity of "afferent origin," we must give all the plus found by skiametry, and often must go to extreme measures to get on more plus than skiametry shows, for the exhausted latent hyperope. To surely differentiate between these two types sometimes requires a high degree of skill, searching analysis of symptoms, careful study of the ductions. Often we can distinguish between them by noting the effect of added plus on the near abduction. The latent hyperope often shows a low abduction at near which is usually considerably increased by more plus, while the other type generally has good ductions and frequently we find the near abduction decreased by added plus. This is not an infallible rule, however, and we find

complications of hyperphoria in many cases that must be dealt with. A full discussion of the details of this matter is not in place here and must be relegated to another paper. But it is a vital part of the subject under discussion.

We now come to that part of the questionnaire that deals with the esophoric latent hyperope who, when exhausted, shows exophoria. "Do they point to the fact that convergence excess at the near in the young adult presages convergence lag in the presbyope?" If this must be answered in the words of the question, the answer must be "No," for terms used assume that which is not true, as we have discussed in previous paragraphs.

But we must answer "Yes," if the questioner will permit us to reword his question in terms that are correct. "Do they point to the fact that a low physiological exophoria in youth is often a forerunner of excessively high physiological exophoria in later years?" Yes, there is authentic data in great amount to verify this. The reasons for this change from esophoria to high exophoria, we have attempted to detail in the preceding paragraphs.

This covers paragraphs one, two, four and a part of three. There is one sentence in paragraph three that must be questioned, but I shall again take the liberty of substituting proper expressions for "convergence excess and convergence lag." "The percentage of esophoric cases found among young patients dovetails with the percentage of high physiological exophoria found in the older ones."

To make such an assertion with any degree of expectation of its acceptance, one would need thousands upon thousands of records accumulated through decades of years. We doubt if anyone has such a mass of records. And for such dovetailing of percentages, no youthful latent hyperope could die, none could be fitted with plus lenses while young, every one would need to be occupied with close work during many years of his life. Moreover, there is the high number of psychic esophores, mentioned in a preceding paragraph, who do not follow this rule of the latent hyperope in changing to high exophoria. This is assumption without basis, entirely unwarranted.

Not every latent hyperope shows a high exophoria at near in his presbyopic days. In my experience I have noticed that the man who does little close work is not very apt to reach the exhaustion stage of high physiological exophoria. Not being under much strain, he does not succumb. There is no reason why he should. And, in passing, I have found latent hyperopes of as high as 60 to 66 years, in one remarkable case of 72 years, of from one to three diopters, whose dynamic skiametry and phoria showings gave no indication of the hidden, or compensated, error. Their tonicities were as high as that of boys in their teens.

Latent hyperopes do not always wait for the presbyopic age to give way under the strain. High physiological exophoria and high tonicity lag are apt to show up at any time. Much depends on the

amount of close work done, the general bodily health, their freedom from worry, and other physical and mental factors.

High physiological exophoria is by no means a proof of "convergence lag." "Exophoria" is not a synonym of "weak convergence." We shall need to define these terms before we go further. Exophoria is a condition of tonicity such that, when binocular fixation is inhibited (as is done when we take the phoria tests by either maddox rod or double prism or by the Landolt method of base-down or base-up up over one eye of sufficient power to prevent bimacular fixation), the visual axis of one eye is permitted to turn away from the line of fixation, i. e., temporalward.

But plenty of persons who show considerable exophoria have no difficulty whatever in convergence. While many who show but very slight exophoria have considerable difficulty in maintaining both maculae beneath their respective images. The function of convergence is to place the two maculae simultaneously beneath the two images. When this is difficult, then we may fairly say that "convergence is weak." Study of cases shows no relation between this "weakness" and exophoria.

To demonstrate "convergence lag," draw two circles on a card about 4 inches high by 7 inches long, the center of these circles 70 mm. apart, the diameter of the circles anywhere from 20 to 30 mm. Now draw a vertical line through the center of each circle, these lines about 10 mm. long. Set in the kratometer or phorometer, at 35 cm. from the eyes, and turn in 10$^{\Delta}$ base-out before each eye, with a septum placed between the two eyepieces, as in an ordinary stereoscope. Normally, these two circles with their vertical central lines will fuse into a single circle with a single vertical line. You will find an occasional person who will fuse the two circles into one but will see two vertical lines. They fuse the periphery but do not fuse the foveal images. This is "convergence lag." It is not rare, but is fairly common among middle aged and elderly people of low body tonicity, is occasionally found in younger people who are not in rugged health. I have not been able to find any indications from the phoria tests that would foretell this finding. It is as apt to occur with normal physiological exophoria as with high. These people always have difficulty with close work and refractive corrections have no effect in reducing their discomfort. Physical exercise, proper food, correct sleeping habits, sometimes medical treatment, are the methods by which comfort is restored.

So we can hardly agree "that convergence excess at the near in the young adult presages convergence lag in the presbyope." But we can say, with authority, that cases of negative physiological exophoria in youth tend to change to high physiological exophoria in later years, when and if the early low, or negative, physiological exophoria is a symptom of hypertonicity through the habit of compensating a struc-

tural hyperopia for the sake of clear vision, when and if such habit results in exhaustion.

To the question in the fourth paragraph, "What is to be done about it?" we can only answer that when the individual begins to complain of fatigue and comes seeking help, it is our duty to completely relax the convergence-accommodation, ascertain what the structural hyperopia is, correct that part of the hyperopia whose compensation demands excessive effort. When this time of fatigue arrives, we shall find the negative relative convergence very low, frequently the near abduction is low. We have learned that that amount of plus that will give the highest near abduction is the amount of plus needed by the patient to prevent fatigue at near work. It is not sufficient to find the amount of plus acceptable for distance. The problem is at near, and the requirements of near work must be satisfied. Such treatment will forestall the appearance of a high physiological exophoria of exhaustion..

Psycho-pathologic cases of definite types have been shown to result in sympathetic system hypertonicities, one of the symptoms being esophoria. This has been mentioned in preceding paragraphs. Pathologic conditions, especially brain tumors in certain areas, have been shown to produce convergent squints, also homonymous diplopia even when actual convergent squint is unnoticed or cannot be noted by an observer. These are, of course, "excessive convergence." "What other factors are causative?" It would seem that the above are all inclusive. The only thing, so far as the present writer has been able to learn, that would cause "excess convergence" is pathologic disturbance.

The fifth paragraph is illogical. The questioner says, "We know that uncorrected hyperopia, hyperopic astigmia, over corrections of minus, prism power base-out, wide interpupillaries and pathology cause excessive convergence." I doubt if we "know it," although some have thought some of these things without so very much reason behind their thinking. Again, we must distinguish between "esophoria" and "excessive convergence." They are not in any way synonymous. Uncorrected hyperopia does not necessarily produce esophoria, but the habit of compensation of hyperopia may, often does, produce that hypertonicity that we call esophoria. The habit of non-compensation of hyperopic error, by the same laws, is often, not always, associated with exophoria. The same may be said of hyperopic astigmia.

Over corrections of myopia, producing the optical effect of hyperopia, often cause esophoria. We have all seen examples of that. Prisms base-out force the visual axes to turn beyond their proper position of intersection in the object of regard, so this may be termed "excessive convergence" when the prisms are in place. But when they are not being worn, there is no "excessive convergence, unless there is a convergent squint manifest when the prisms are taken away. Prisms base-out when prescribed for esophoria or esotropia tend to increase the amount thereof, that has been demonstrated.

Wide pupillaries do not cause excessive convergence or esophoria or myopia. That theory has been thrown into the discard by the experiments of several German ophthalmologists and neurologists during the past five years.

Convergence, versions, convergence-accommodation, "fusion," "stereopsis," all eye adjustments, with the exception of pupillary reaction to light, are muscular acts and associations learned by each individual by experiment, by trial and error, just as are walking, running, use of the hands in various acts, etc. Each individual learns to use his own muscles, adapts himself to his individual structure. To assume that a man with an unusually wide interpupillary distance develops an esophoria because of that reason is to assume that some mechanic had devised a machine that would produce perfect binocular coordination at some fixed interpupillary distance and that all variations from that fixed measurement must be provided with a separate compensating device. Of course, that is ridiculous on the face of it. But this is only one of the equally farcical theories that fill many pages of our books.

Paragraph 6: "Does a convergence excess at near always keep company with a faulty, incomplete, or imperfect fusion sense?" To repeat Dr. Hoare's excellent reply, "We can see no connection." We are without an understanding of what the questioner means. By "convergence excess," does he mean convergent squint? That is the only form of "convergence excess" that is known, save the artificially forced excess when base-out prisms are used. Or does he mean a near point esophoria? And what does he interpret as a near point esophoria? Will he include, as many of us do, a case in which the physiological exophoria is less than 4^{Δ} to 6^{Δ}, or does he limit this type to those who, in the phoria test, let one eye turn inward?

Judging from the context, the previous questions, we assume that he means by "convergence excess" that which we commonly call "esophoria," for anything else would be squint. Whether in near point esophoria he includes those with a low physiological exophoria need not now be considered.

The esophore can scarcely be said to be lacking in "fusion sense," for he maintains single binocular vision against strong odds. The moment he ceases this bimacular fixation he becomes an esotrope, shows a convergent squint, or he suppresses the vision of one eye. He suffers because of his insistence on bimacular fixation, endures torture rather than suppress or squint. He could rid himself of his headaches and other discomfort by suppression, but this consolation he refuses. Understanding that the questioner means "esophoria," the answer to the question is an emphatic "No."

Then we come to paragraph seven, asking if this "faulty fusion sense" may be the cause of the high physiological exophoria of later years. As we have already discussed the origin of this, it is only necessary to say "No" to this question.

From the wording of this sentence we might infer that the questioner has based it on the ancient theory that accommodation carries convergence. Present day psychologists are in unison in discarding all these theories and regard the act of binocular fixation and focusing as a single reflex. The term in use is "the visual attention reflex." We can say, not that accommodation carries convergence, but that the need for accommodation, or focusing, is at the root of the combined convergence-accommodation act, or visual attention reflex. Possibly this is what was meant by the earlier writers who found the two functions were in union. Their statements may have been misinterpreted, misstated, by others. That we do not know. It is very common to find an author credited with a statement he never made. His words assembled in another form, with one or two omitted, or one or two added, give an entirely different thought from that he himself wished to convey. That is where so many of these untrue expressions arose, such as "convergence excess" and "convergence lag." The worker is misquoted by the theorists.

In the eighth paragraph we have a few statements and a question that may well be discussed. "We know that over-corrections of plus, especially reading corrections for presbyopes, and base-in prism power gradually bring about convergence relaxation, which can result in convergence lag." It is true that sometimes over-corrections of plus are followed by the true convergence lag described in preceding paragraphs. Also, I have seen undercorrections followed by equally uncomfortable symptoms. And I have seen what at first seemed an over-correction prove to be just what was needed to reduce a high exophoria considerably because of the rest afforded. I have seen such apparent over-corrections dispel true convergence lag. The sentence as it stands is capable of misinterpretation. We ask, what does the questioner mean by "over-corrections"?

He says: "Base-in prism power * * * can result in convergence lag." True, when such prisms are improperly prescribed as the optical correction of a high exophoria. That is exactly what such prisms do, they increase the exophoria and I have seen true convergence lag follow. But properly prescribed base-in prisms, given as an inhibition to a straining convergence-accommodation reflex together with proper plus spheres, or base-in prisms given as an inhibition to psychopathic esophoria, do not tend to increase an existing high physiological exophoria. Quite the contrary, the exophoria decreases as the stress is inhibited. In all this work, we must distinguish between the many types of exophoria, think of the origin of that type found in the individual patient. Such all inclusive sentences as this, and the one referred to in the preceding paragraph, would not then be written.

"Do small segment bifocals tend to cause convergence lag by the disturbing effect they may have on near point fixation? Are large segments conducive to easier near point vision when there is convergence lag present?" The answer is "No, not in nor because of the size of the segment."

The diameter of the wafer determines the position of the optical center of the reading segment of a bifocal. The smaller the wafer, the higher the optical center. Conversely, with large wafers the reading optical center is thrown to a low point. If the optical center is below the point through which the reader looks, he is reading with base-down prisms before his eyes. Convergence is in and down. Tscherning found that the average person drops the eyes, when reading, so that the visual axes pass through the lenses at 6 mm. below the points through which the person looks when fixing objects in the medium distance. He therefore laid down the rule that the ideal bifocal should be so adjusted that the distance optical center is intersected by the visual axes during distance vision and that the reading optical center should be 6 mm. below this. This position of the optical center of the reading segment is determined by three factors, the power of the distance correction, the power of the addition, the diameter of the wafer from which the segment is made. The recent introduction of small segments has for its object the control of the position of the optical center of the reading segment by the size of the wafer. It is aimed at the elimination of base-down prisms before the reader's eyes. For such prisms inhibit convergence and convergence-accommodation, make reading uncomfortable. To give a high exophore large segments that carry a base-down effect is to render him uncomfortable.

The prescription of large segments or small segments, aside from this prism factor, rests on the habit of the individual. Lindsay Johnson has shown that he who turns the head when reading can use very small segments, while he who turns the eyes only needs long segments. It is now possible to make long segments with the base-down effect of the earlier types eliminated.

The greatest help we can give to the presbyope with high physiological exophoria is to fit him with bifocals in which the optical centers of the reading segments are above his line of vision when he is looking down at book or paper. These incite convergence—it is better to say that this base-up prism effect incites the convergence-accommodation reflex.

If the questioner has had difficulty with high exophores because of small segment bifocals, we suggest that he do not decenter them in, but order them made "on line." Then he will give his patient a slight base-out effect, which is a good inciter to the convergence-accommodation reflex, since, after all, this reflex is in fact the cultivated response to images falling on the temporal sides of the foveas.

One great difficulty seems to be a suspension, either of one eye or possibly alternating, when there is a true convergence lag. Then, of course, with low tonicity, visual axis of the suspended eye tends to diverge slightly, for a moment, from its correct position of direction toward the object of regard. This can be readily checked, or observed, by the corneal microscope. Then our reader with small segments might have some trouble with the margins of the segment. That,

however, remains to be proved. Another suggestion in response to the question is that any annoyance that tends to disturb the elderly person will result in fatigue which makes itself known as a high physiological exophoria. So if these bifocals do annoy, after the manner or because of the factors mentioned, there is an explanation of the exophoria the questioner's sentences suggest he has found.

In the ninth paragraph the question indicates an assumption that the questioner will have much difficulty in proving. "Base-in only tends to convert one distressing condition (esophoria) into another (exophoria) over a period of years." I have taken the liberty of substituting the terms the questioner means instead of those he uses; "esophoria" for "convergence excess," "exophoria" for "convergence lag."

We give base-in prism to esophores as a physiological measure to inhibit the excessive tonicity flow to the convergence muscles, to establish tonicity balance between these muscles and the abducens muscles. The writer has seen no case where the use of such prisms over a long period, six or eight years, or less, has resulted in an abnormally high physiological exophoria. But I have seen cases where the misguided use of base-in prisms has been followed by such result. In the earlier days of these experiments, fearing just such misfortune, I undertook to remove the prisms as soon as the esophoria disappeared. Found it was not wise to remove them, for the tendency to esophoria reappeared, the distress of the patient returned.

We know well that the use of prisms is fraught with peril. For that matter, no less are the dangers surrounding the prescription of plus or minus spheres, plus or minus cylinders, colored lenses, or anything else we have to use in our work. I do believe that the prism wearer should return for frequent check, and I also believe that the wearer of any kind of lens should return for frequent check, instead of the classic "two years" that the average practitioner suggests to his patient.

"Should not the use of such procedure always be accompanied by fusion training?" Now it is our turn to ask a question—Why? Does the questioner confuse prism exercises with "fusion training"? We may have misunderstood his question, but that is the way it sounds.

Prism exercises are not necessarily "fusion training," though they may be used for that purpose. We use prism exercises to establish correct habits of reciprocal innervation, among other things. That has nothing whatever to do with "fusion training," since in those cases rarely is there any diffculty about "fusion." Sometimes we can establish proper reciprocal innervations with prism exercises, but rarely. As a rule the continued inhibition of constant prism wearing is essential. Sometimes, generally, prism exercises in connection with the use of inhibitive base-in prisms speeds the establishment of comfort for the patient. We use base-out prisms to excite the visual at-

tention reflex arcs, and base-out exercises are very helpful in this. But in this there is no "fusion training." So we must ask the questioner to be more explicit and tell us what he is talking about.

Tenth paragraph: "Is the correction of a faulty fusion sense the surest and sanest way to establish comfortable ocular balance?" Why, of course, if that "faulty fusion sense" is the cause of the discomfort. But such cases are in the vast minority of those who come to us seeking relief from intolerable eye strain. "If so, should not all orthoptic training stress the development of greater fusion power?" We ask a definition. What is "greater fusion power?"

The questioner does not state whence come some of the thoughts expressed in his questions. It would seem that he has taken a great deal of trouble to get together many of the strange philosophies current now and in the past and put them into such form as should make us all realize how illogical most of them are. If this was his thought, he has surely performed a meritorious deed. Nothing could show more clearly the pressing need for the systematic gathering of data, for the definition of the terms in our professional vocabulary, for the elimination of abstruse theory and misleading terminology.

While the present writer may have appeared somewhat categorical and dogmatic in the presentation of his own thought on these questions, he does not feel at all that way. It is rather with a profound skepticism of all the theorizing of the past that he presents the findings gathered in his own experience. We want facts; we have had too much theory. We have not enough data to be able to establish any theory, hypothesis or postulate. Most of the theories we have had thrust upon us do not agree with the facts we have at hand. What optometry needs most, if it would solve the problems of binocular discomfort, is authentic research by competent men. When we undertake such research, then we shall take our place on a par with other professions, but how can we expect it before we make such contribution?

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OCULAR ELECTROTHERAPY

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THE PHYSIOLOGICAL EFFECTS OF THERAPEUTIC CURRENTS

CHAPTER XI.

The Effect of Electricity on the Muscles

From the discussion in the preceding chapters, it is reasonable to conclude that physiologic activity is the equivalent of electrical stimulation, then electricity is the means by which cells are organized. ***Muscle cells become disorganized*** when the nerve supply is cut off, but the application of electricity will reorganize them, claims Crile. If groups of muscles are not used they become disorganized and weak. It is probable that the exercise set in motion electric forces by means of which cells and abnormal muscles are built up into all around physical efficiency. Children who are not allowed to play are usually not developed very strongly; that is, their muscles are not organized by the electric energy of exercise and there is usually a marked improvement noticed as soon as these children begin to play and exercise.

Next in the value of exercise, which stimulates the nerve cell and furnishes energy to the muscles, is electric stimulation of the muscle. Electric stimulation restores the muscles quite as well as voluntary stimulation, but it does not as readily reorganize and build up the deteriorated nerve cells. These statements have been sufficiently proved by clinical experience, especially by the results obtained with electrotherapy since the world war.

The severing of the nerve connection between the brain and a muscle leads not only to paralysis, but to atrophy of the muscle; but if through electrical stimulation the muscle is made to contract at certain intervals, atrophy of the muscle will not set in.

From the discussion in the preceding pages of the "electrical nature of nerve impulses" we may find a reasonable explanation to an oft repeated statement, *"it feels fine,"* so often made voluntarily by the patient when ocular diathermy or high frequency current is applied. From a biological standpoint a pleasant feeling is connected, with ***beneficial stimuli*** and ***a good condition of the organism*** and unpleasant feelings, ***with injurious stimuli*** and ***poor bodily condition.*** Authorities differ as to the manner in which feelings are generated. The question is raised, "is feeling a sensation,[42] which originates in the excitation of sensory nerve ends, and are there

specific nerves and sense-organs for feeling"; or "can all or most of the different nerves convey impulses to the brain which are capable of arousing these forms of consciousness"; or "do pleasantness and unpleasantness arise from the brain itself?" Meynert[43] claims that feeling is an indication of the nutritive condition of the brain, especially as dependent on the blood supply. Lehmann[44] contends that *pleasant feelings is the index of a proper balance between the supply and expenditure of energy by nerve cells of the brain; while unpleasant feelings result from an excess of expenditure over supply.* Therefore, every extremely intense sensory stimulus is unpleasant because it overworks some of the brain cells, causing their expenditure of energy to exceed the supply brought to them by the blood stream. Considering the effects of high frequency and diathermy which are increased blood circulation, restoring the balance of energy supply, improving conductivity of nerve energy to the muscles, massaging the individual cells, etc., one can see the explanation for the cause why the patient so often during the course of a treatment claims that he feels so much better, no matter whose explanation about feeling we accept.

Muscular Response

Muscular contraction is more readily elicited through electrical excitation than through any other means. Massage may have some stimulating effect, however, it is very small because massage stimulates only surface circulation and has, therefore, little influence upon the muscles. Kellog[45] claims that the muscles constitute one-half of the bulk of the body and receive one-fourth of all the blood of the body, and while the muscle constantly receives a certain supply of blood, it is very small except for the time when the muscle is active. It may, therefore, be stated that *"the muscles are best fed only when exercising."* The blood goes around the muscle instead of through it when it is inactive.

In studying the action and characteristics of the muscles, Hill and Hartee[46] make this very interesting analogy between energy exchanges in muscles and in an electro-magnet. This analogy is claimed by other observers to be an identity. In their analogy they state that this is not a theory of contraction, but merely a physical analogy to what has already been proved in regard to the muscle and its energy relations. The analogy is a very close one, and a close analogy may be valuable in suggesting lines on which further progress can be made, as well as in showing that a certain type of mechanism is possible.

Consider an electro-magnet attracting a piece of soft iron. To make the magnet exert this attraction a current has to be passed, and energy has to be expended in magnetizing the electro-magnet; to maintain the attraction it is necessary to maintain the current and the expenditure of energy. On breaking the current in the electro-magnet the attraction disappears, while the magnetic energy of the

electro-magnet and of the magnetic field vanishes as such and reappears as heat caused by induced currents. Suppose further that the current was obtained from an accumulator; in order to recharge this accumulator it is necessary to employ some kind of engine to turn a dynamo and in this recharging process heat is liberated in the engine and "free" electric energy is stored in the accumulator.

Store of Free Energy Capable of Being Liberated Without Oxidative Changes

The accumulator can have its energy released merely by pressing a key and making an electric contact, just as the muscle can have its energy released by giving it a shock. The chemical changes liberating the energy of the accumulator do not involve any oxidative breakdowns, just as the initial processes of contraction in the muscle do not. The energy of the accumulator may be liberated largely as mechanical potential energy or work, or on the other hand if the accumulator be short-circuited it may be wasted as heat; the muscle's internal energy similarly may appear as potential energy or work.

Development and Maintenance of Mechanical Response

Directly the key is pressed down the current starts in the coil of the electro-magnet and the magnetic attraction develops. The current, however, does not immediately rise to its full value, owing to the self-induction of the coil nor does the soft iron of the magnet become magnetized instantaneously under the influence of the magnetic field of the coil; hence the attraction exerted by the magnet on the piece of iron increases gradually up to a certain limit and then remains constant; these phenomena are similar to those shown by a stimulated muscle. Moreover, if the current be left on too long the accumulator becomes polarized, the current falls off and the magnetic field decreases; while if the accumulator be given a period of rest it recovers and provides its full electro motive force again and the magnetic field rises to its previous value. The phenomena of muscular fatigue are analogous.

Performance of Work

The current in the electro-magnet develops a store of magnetic potential energy in the soft iron core and in the field around it. This magnetic energy will do external mechanical work, if allowed, by pulling up the piece of soft iron to the magnet. On the other hand, no external mechanical work is done if the piece of iron be held fast. In the same way the muscle develops elastic potential energy on excitation; this energy may result in external mechanical work if the muscle be allowed to shorten, but in an isometric contraction no external work is done. The work actually performed depends, in both cases, on the "conditions of loading."

Heat Produced In the Disappearance of the Mechanical Response

When the Electro Motive Force in the circuit of the electro-

magnet is removed the potential energy of the magnetic field disappears in the process of inducing a current in the coil of the electro-magnet or in neighboring conductors, the energy of this current being dissipated finally, is heat. Thus, when we remove the E. M. F. exciting the electro-magnet there is not a cessation of the heat-production; the heat-production continues until the whole of the magnetic energy of the field has been dissipated as heat through the intermediation of induced currents. Similarly in the muscle, as shown in this paper, when the stimulus ends the heat-production does not stop at once; it continues until all the elastic potential energy of the muscle has disappeared.

The Recovery Process

The whole of the phenomena described above are independent of the immediate presence of oxygen. When however it is required to recharge the accumulator an engine is started up, oxygen and fuel are consumed, heat and mechanical energy are liberated, a dynamo is turned and current is produced. Similarly in the muscle, when recovery is necessary some mechanism removing lactic acid is set in motion, oxygen is consumed, heat is produced and the muscle is restored to its previous condition.

Muscular Fatigue and Its Removal

Helmholtz, DuBois-Raymond, Ranke and others more recently have shown that when a muscle is overworked special toxic substances are produced which cause fatigue of the nervous and muscular systems.

Abelous thinks that the effect of fatigue is a sort of auto-curarization, or paralysis of the terminal motor plates of the nerves which actuate the muscles. In advanced fatigue, the muscle itself is exhausted by the consumption of the material (glycogen) which is necessary for efficient and comfortable work.

In cases of this kind where there is an auto-curarization of the terminal motor plates, due to fatigue, the flow of nerve energy to the muscle is considerably slowed up or stopped altogether. The application of high frequency current will *energize the terminal motor plates, this will result in an improved flow of nerve current to the muscles and thus restore the functioning power to the fatigued muscle.*

When the voluntary muscles or various glands of the body have their nerve supply stimulated by electricity they will respond exactly in the same manner as if the stimulus were sent from the brain. Gotch and Horsley observed that if the motor area of the cortex of the brain is stimulated by electricity, the result will be muscular activity which resembles ordinary voluntary activity, such as bending of the wrist, the elbow, the knee, turning of the head, turning of the eyes, etc.

Crile[47] states that electricity does for the muscle as far as its function and nutrition are concerned what the brain does for it.

Therefore, electricity is adapted to the muscle and the muscle is adapted to electricity. From the previous discussion, we may safely conclude that physiologic activity is the equivalent of electrical stimulation and that electricity is the apparent means by which cells are organized. When any part of the body is injured, the muscles and nerve cells become disorganized and voluntary exercise will best reorganize them again. Next in value to voluntary exercise is electric stimulation of the muscle. This form of stimulation restores the muscle equally as well as voluntary stimulation, but it does not quite as readily reorganize and build up the deteriorated nerve cells.

The Electric Current Within the Eye

A ray of light entering the eye upon reaching the retina sets up a photo-chemical reaction which is transformed at the layer of rods and cones into an electrical current. This current travels through the accumulator cell to the brain, from the brain to the muscle and from there to the liver—the point of lowest potential and from this point back to the brain again, through the electrical fluids permeating the organism. It thus makes a complete circuit as can be seen in figure 14.

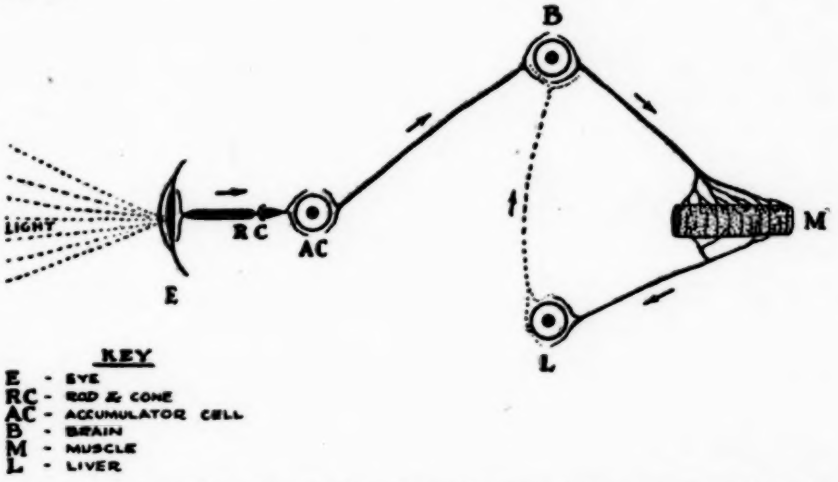

Fig. 14. Schematic plan of the theoretic complete sensory motor circuit. (Courtesy G. W. Crile.)

The difference in response of the ocular muscles can thus be explained from an electrical standpoint, as Loebs states, in his discussions of the various electrical phenomena, that "We must, therefore, conclude that the light produces in an eye or an element of the photo-sensitive skin a chemical reaction which results in the formation of a certain mass of a reaction product. This mass acts on the peripheral nerve endings and brings about an as yet unknown change in the brain elements with which these nerve endings are connected. This change in turn affects the tone or tension of the muscles with which the brain elements are connected. When the rate

of photo-chemical reaction is the same in both eyes or in the photo-sensitive elements on both sides of the body, the change of tone in the symmetrical muscles of both sides of the body is the same and no change in the position or direction of motion of the organism should occur. If the rate of illumination is different in both eyes, differences in the relative tension of the symmetrical muscles occur, which make the motion to the source of light easy and in the opposite direction more difficult when the animal is positively heliotropic. For the negatively heliotropic animal the opposite effect will be brought about."

Crile[48] goes a step further and claims that there is a very marked relationship or identity between light energy and electrical energy and to prove his contention he gives these facts:

"That there is increasing evidence that the original unit of living matter was organized from the inorganic elements of the sea by means of electric energy or sunlight; that living organisms, even those whose lives are spent in apparent darkness, live in a world the atmosphere of which is constantly subjected to a bombardment of electrons from the sun; that the energy of heat and light is essential for the production of chemical action; that the energy transmitted through one of the most delicate and intricate mechanisms in man as the result of the impact of light waves, has been demonstrated to be electric energy. It is therefore fitting that we consider briefly the physical qualities of light, and its biological effects in their relation, to be a bi-polar mechanism.

"According to the electronic theory, 'light waves' are electric waves, and the light of the sun is electric energy transmitted by the constant emission of electrons from the vast number of electrons constantly vibrating within the body of the sun itself. *Light, then, is electricity, and the effects of light are the result of the application of its electrical energy and are to be interpreted by the laws which govern electrical energy.*

That sunlight is electricity is shown by its capacity to induce positive charges. This has been demonstrated by Nodon in his observations of the electric action of the sun and moon, from which he concludes that 'the sun induces a positive electric charge' and that 'the full moon produces a positive electric induction analogous to that of the sun.'"

The phenomena of heliotropism as demonstrated by Loeb and his conclusions therefrom are strong arguments in favor of the assumption that the animals thus activated are electric mechanism and that the energy that activates them is electricity.

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OCULAR PHYSICAL AGENTS

It has ofttimes been said that a lens is not a "pill," yet it is without a doubt a Physical-Agent, when prescribed to correct a visual defect, and the optometrist who prescribes it is therefore practicing a form of physical therapy, the effects of which have an unquestioned far reaching effect on the entire nervous system.

I have just said that in prescribing an ophthalmic lens the optometrist performs an act in physical therapy. This is true in the broad sense of the term just as much as though he had applied hot packs to the eyes or had used a form of ocular massage to increase the circulation of blood, to these organs. Physical therapy, it must be understood, includes any technic wherein a physical element or remedy is used to stimulate, repress or in any way change normal or abnormal physiological action.

The foregoing being true, it is therefore obvious that optometrists as a whole are unquestionably one of the largest professional groups in existence today using a form of physical therapy and it is not surprising therefore to find this group gradually supplementing its hitherto purely optometric forms of physical therapy with other types of physical therapy which seemingly aid in correcting certain cases such as cataract, amblyopia and muscular imbalance, etc.

Diathermy, for instance, can be of great advantage in cases of crystaline opacities particularly where extraction is undesirable. The application of this agent when properly applied is painless, devoid of risks to the patient and the course of treatments can be continued as long as is desired. Shelly[1] apparently was the first one to make

use of diathermy in the treatment of cataracts. He proceeds on the assumption that "high frequency oscillations being propagated in the tissues due to ions whose orientation and movements are constantly modified by the passage of the current, must produce a sort of molecular massage, stirring cells and clearing them of waste products, which are replaced by new and healthy material."

Investigators are now becoming more fully convinced that physical therapy agents are the only hope for the control and treatment of cataracts, in view of the fact that medication has proven of little or no value. There are to date a number of cataract cases on record successfully treated with physical therapy agents[1]. Cox for instance, reports favorable results in a number of cases, as follows:

"Mrs. S., age 75, came to him with a developed cataract of unknown duration; the eye always bad in vision. She was given a course of sixteen treatments, and two months later, thirteen more, using his special technic. The opacity cleared so that the eye gives good general vision and, the lady claims, is better than ever. It has remained good for two years and shows no evidence of recurring."

Therapeutic currents such as high frequency, diathermy, massage, etc., are not the only physical agents used at present in the treatment of cataracts. The writer,[2] Hotaling and Melvin advised the application of Calobar Lens therapy to if possible arrest the development of lenticular opacities. Committees appointed by the American Academy of Optometry are now studying the effects of the application of these physical agents—therapeutic currents and Calobar Lens therapy. Both of these agents deal with application of radiant energy in different forms and are therefore naturally within the scope of the practice of Optometry.

Kurtz also reports some success in the application of physical therapy agents in the treatment of Amblyopia, a case in point is Mrs. T., age 52, called for a refraction June 13, 1929. She claimed that she has been blind in the left eye for several years and that she has been losing the sight of the right eye for the last few months. She visited several ophthalmologists but was told that nothing could be done to save the sight of the right eye. The ophthalmoscopic examination revealed atrophy of the left optic nerve. The fundus of the right eye was apparently normal, with a slight cupping of the disc. Static Skiametry O. D. — 6.00 D. Sph. ⊃ 3.00 D. Cyl. Axis 30. O. S. — 9.00 D. Sph. Dynamic Skiametry O. D. — 3.50 D. Sph. ⊃ — 3.00 D. Cyl. Axis 30. O. S. — 7.00 D. Sph. Vision without lenses O. D. Fingers at 8 feet and O. S. light perception only. Vision with static skiametric findings was O. D. 20/200; O. S. light perception only. The correction worn for the last 12 years was O. D. — 4.00 D. Sph. 4.00 D. Cyl. Axis 180. V = 10/200; O. S. — 8.00 D. Sph. which did not improve vision.

The case was diagnosed as a case of amblyopia in the right eye, and amblyopic treatments were instituted. A combination of physical agents consisting mostly of high frequency and diathermy of

varying technics were used, all treatments were given twice daily, for a period of one month. The following lenses were prescribed: O. D. — 4.50 D. Sph. ⊃ — 4.50 D. Cyl. Axis 30; O. S. — 9.00 O. Sph. During the first two weeks there was little improvement in her vision, after this period, improvement was rather rapid. The notes on his records are as follows: July 1, 1929, with above correction, O. D. V = 20/100. O. S. no change during the entire treatment period; July 5th, O. D. V = 20/70; July 9th, O. D. V = 20/50; July 13th, O. D. V = 20/40. The patient being a farmer's wife, living a few hundred miles from Minneapolis had to return back to the farm at this time although she expressed the desire to continue the treatments for a longer period and she promised to return for treatment within the next three months as soon as the farm work was completed. On October 21, 1929, the patient again reported at the office claiming that the sight now is not nearly as good as when the treatments were discontinued. Upon examination it was found that the acuity of vision in the right eye had dropped to 20/100 during the three months she was away. A search for the cause of the reduction in visual acuity was made as Kurtz suspected some foci of infection and while the patient claims to be strong and healthy and looks the part she was sent to a reliable physician for a complete medical examination. The report of the examination was that there is some definite foci of infection and the patient was advised to have that condition attended to. Treatments of ocular physical agents were again instituted and the sight is gradually improving.

Due to their physiological effects therapeutic currents are extremely helpful when applied as a complement with regularly accepted technics in squint cases and other muscular abnormalities. Grover[4] even goes a step further and states that "It is claimed by those who are familiar with high frequency application that this current alone often corrects mild cases of muscular imbalance." The improvement in muscular imbalance cases through the application of physical agents and therapeutic currents—especially is explained on the basis that certain toxic conditions will cause auto-curarization of the terminal motor plates of the nerves which actuate the muscles. In cases of this kind the flow of nerve energy to the muscle is considerably slowed up or stopped altogether, just the same as the power of your radio set is affected when the terminal of the "A" battery becomes corroded. The application of therapeutic currents will energize the terminal motor plates. This in turn will result in an improved flow of nerve current to the muscles and thus restore their normal functioning power.

With the increase of the store of our knowledge and clinical experience in physical therapy—a new field for study and research is opened up to optometry. Some of the subjects which lend themselves best to investigation from an optometric standpoint[3] are: (a) The effect of diathermy in restricted color fields. (b) The effect of

diathermy in lenticular opacity cases. (c) The effects of diathermy in opacities of aqueous and vitreous humor. (d) The effect of diathermy or high frequency in pseudo-myopic cases. (e) The effect of diathermy or high frequency on abduction and adduction. (f) The effect of diathermy or high frequency on styes and tumors of the lid. (g) The effect of diathermy or high frequency as a pain relieving agent. (h) The effect of diathermy or high frequency in amblyopia. (i) The effect of ultra-violet in cases of myopia and pseudo-myopia. (j) The effect of Rapid Sinusoidal on Optic Atrophy. (k) The effect of Rapid Sinusoidal in Amblyopia. Members of the American Academy of Optometry Committee on Physical Agents are now experimenting with some of these subjects.

In other words what is frequently happening in Optometric offices today is the blending of physical agents or remedies. No one form of physical agent is entirely relied upon, the practitioner rather using several forms of physical therapy to secure more readily the results sought after. C. C. K.

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ANNOTATIONS AND SOCIETY PROCEEDINGS

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THE INSTITUTE OF APPLIED OPTICS OF THE UNIVERSITY OF ROCHESTER

During the late spring of this year (1929) a long cherished dream of those interested in optical and optometric education was realized in the establishment of the Institute of Applied Optics of the University of Rochester.

The establishment of this Institute of Applied Optics represents the outcome of a decade of planning, and it has the unique distinction of being the only university institute providing a comprehensive curriculum in optics and optometry with individual administrative and financial control. This control is centered in two committees, each being equally representative of the University of Rochester, the Bausch & Lomb Optical Company and the Eastman Kodak Company.

Beginning September 1, 1930, the Institute will be exclusively housed on the third floor of the John J. Bausch-Henry Lomb Memorial building, one of the new structures of the $10,000,000 building program of the University of Rochester, now nearing completion. This space, representing upward of 9,000 square feet, will be occupied by the Optometric Clinic, Optical Shop, Geometric Optics Laboratory, Physical Optics Laboratory, and several smaller laboratories for advanced work in spectroscopy, colorimetry, photometry, etc. Class and lecture room facilities are provided for on the first and second floors of this building.

The Institute offers courses of instruction to two distinct groups

of students; first, those desirous of preparing themselves to meet the requirements for licensure in optometry, and second, those interested in the industrial, research or instrument-manufacturing phase of optics.

Students in optometry have been registered by the University of Rochester each year beginning with September, 1926, so that the Institute of Applied Optics will present its first graduating class on commencement day in June, 1930.

There are several features of the optometry course which those responsible for its curriculum believe worthy of mention. First, the sequential arrangements of prerequisite subjects seem adequately provided for. Physics, chemistry and mathematics being included in the freshman year makes possible the completion of the courses in Geometric, Physical, Physiologic and Ophthalmic Optics during the sophomore and junior years. In addition to this, the course in Physical Education which is included in the freshman and sophomore years provides instruction in hygiene, and this, with the courses in Biology, General Anatomy and Physiology included in the sophomore year, provides the foundation for Ocular Anatomy and Physiologic Optics to be given during the junior year and Ocular Pathology in the senior year.

Thus, by this system of prerequisites, the foundations in all branches of the course are so thoroughly laid that the senior year can be efficiently devoted to intensive courses of distinctly optometric practice value. Thus the senior students will not only be in a position to devote an adequate amount of their time to clinic practice, but they will also be prepared to enter into the intelligent discussion of case histories in which the problem of co-ordinating functions is emphasized.

Secondly, opportunities for research and graduate work are made possible by the close proximity of the exceptionally effective departments of Physics, Biology, Psychology and Physiology and the Schools of Medicine and Dentistry.

The inauguration of the Institute of Applied Optics of the University of Rochester should give unbounded professional satisfaction to all optometrists, and especially because optometry has been given so prominent a part in the scheme.

Not only is the University of Rochester proud of the founding of this course as it is represented in its present status, but it will endeavor, with the administrative and financial assistance of the Bausch & Lomb Optical Company and the Eastman Kodak Company, to build and expand the Institute to the point of international prominence as the educational factor involved in strengthening Rochester's claim to being the Optical Center of America.

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CLASSES IN OCULAR-PHYSICAL THERAPY

Dr. J. I. Kurtz, Associate Editor of the American Journal of Optometry, will give a series of lectures and demonstrations on the application of Ocular Physical Therapy, before several groups of Optometrists in the Eastern and Central

states. His first lecture will be before a group of Massachusetts and American Academy of Optometry men on Thursday, December 19th, at the Statler Hotel in Boston. On the 20th at the same hotel, he will lecture to a group from Vermont state. On the 22nd he will lecture before a group in Newark, New Jersey. From this point the itinerary is not as yet complete in detail. However, classes will be held in addition to the foregoing at Philadelphia, New York City, Chicago and Indianapolis. Dates and the names of hotels will be announced as soon as arrangements and reservations are completed. Registration in each group is limited, some groups already being filled. For further information inquiries should be sent to Dr. J. I. Kurtz, American Journal of Optometry, Yeates Building, Minneapolis, Minnesota.

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UNIVERSITY OF CALIFORNIA

The Division of Optometry at the University of California opened with a record enrollment. The juniors and seniors have all returned to complete their programs.

With the advent of increased enrollment the Optometry Division is equipping new refracting rooms, which will make seven in all, when completed. The Optometry Clinic is running two mornings a week this semester and the calendar is always full. Next Spring it is planned to increase this to three mornings a week, and when the future seniors get started in the Fall it is quite probable that the Clinic will be open every morning.

The Clinic is open to all students, faculty members and their wives and others connected with the University. Each case is studied carefully and the results have been very successful. The senior students make complete eye examinations which are verified by F. L. Mason, M. A., and A. R. Reinke, A. B., lecturers in Optometry, University of California.

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MICHIGAN OPTOMETRIC CONVENTION

The Michigan Society of Optometrists' Convention was held October 8th, 9th and 10th, inclusive, at Flint. The convention was officially called to order by its president, Dr. Chas. Van Sluyters, at 10:30, October 8th. A number of very interesting and instructive lectures were delivered during the convention. Dr. J. W. Gould of Battle Creek lectured on the use of the "Ophthoscope and Condition of the Fundus." Dr. William Needles lectured on "Optometric Routine Examination," and on the subject of "Education."

The usual committee reports were presented, after which the election of officers took place. The following were elected officers for the coming year: President, Charles Van Sluyters, Grand Rapids, Mich. (re-elected). First Vice-President, G. C. Williams, Kalamazoo, Mich. (re-elected). Second Vice-President, C. Leo Scholler, Big Rapids, Mich. Third Vice-President, Clifton DeGraff, Monroe, Mich. (re-elected). Fourth Vice-President, Joseph Krziza, Dowagiac, Mich. Secretary, Ernest Eimer, Muskegon, Mich. (re-elected). Treasurer, Glenn C. Hill, Detroit, Mich. (re-elected).

Evolution of the

UNCORRECTED AREA
ORDINARY FUSED BIFOCAL

1. *This lens is uncorrected for marginal rays. Only a small part of the reading area is free from astigmatic errors.*

COLOR ABERRATION
ORDINARY FUSED BIFOCAL

2. *Color fringes are inherent in an ordinary fused bifocal. They are added to the marginal errors in the reading portion.*

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